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ARMY ENGINEER WATERWAYS EXPERIMENT STATION VICKSBURG MISS F/G 8/8
WATER-QUALITY AND RAINFALL DATA COLLECTED WITH AUTOMATED FIELD --ETC(U)
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MISCELLANEOUS PAPER M-76-22



WATER-QUALITY AND RAINFALL DATA COLLECTED WITH AUTOMATED FIELD STATION, FORT McCLELLAN, ALABAMA

by

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December 1976

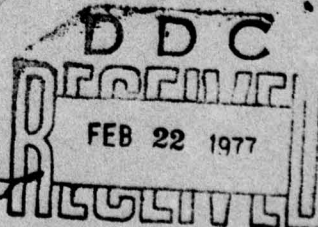
Final Report

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Prepared for Facilities Engineering
Fort McClellan, Alabama

Under Fort McClellan Environmental Program



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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER Miscellaneous Paper M-76-22	2. GOVT ACCESSION NO. <u>14 WES-MP-M-76-22</u>	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) WATER-QUALITY AND RAINFALL DATA COLLECTED WITH AUTOMATED FIELD STATION, FORT MCCLELLAN, ALABAMA.	5. TYPE OF REPORT & PERIOD COVERED Final report	
7. AUTHOR(s) Margaret H. Smith, Herman M. Floyd Harold W. West	6. PERFORMING ORG. REPORT NUMBER	
9. PERFORMING ORGANIZATION NAME AND ADDRESS U. S. Army Engineer Waterways Experiment Station Mobility and Environmental Systems Laboratory P. O. Box 631, Vicksburg, Miss. 39180	8. CONTRACT OR GRANT NUMBER(s)	
11. CONTROLLING OFFICE NAME AND ADDRESS Commander, Facilities Engineering Fort McClellan, Ala. 36201	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS Fort McClellan Environmental Program	
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)	12. REPORT DATE December 1976	
	13. NUMBER OF PAGES 30	
	15. SECURITY CLASS. (of this report) Unclassified	
16. DISTRIBUTION STATEMENT (of this Report) Approved for public release; distribution unlimited.		
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		
18. SUPPLEMENTARY NOTES		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Data collection Meteorological data Fort McClellan, Ala. Rain and rainfall Instrumentation Water quality		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report briefly describes the system of instruments used to collect water-quality and rainfall data at one site at Fort McClellan, Alabama. Water-quality data include concentration of hydrogen ions (pH), dissolved oxygen, conductivity, water temperature, and transmissivity. Pictorial illustrations of the instruments used and examples of the data collected from 12 November 1975 through 27 May 1976 are presented.		

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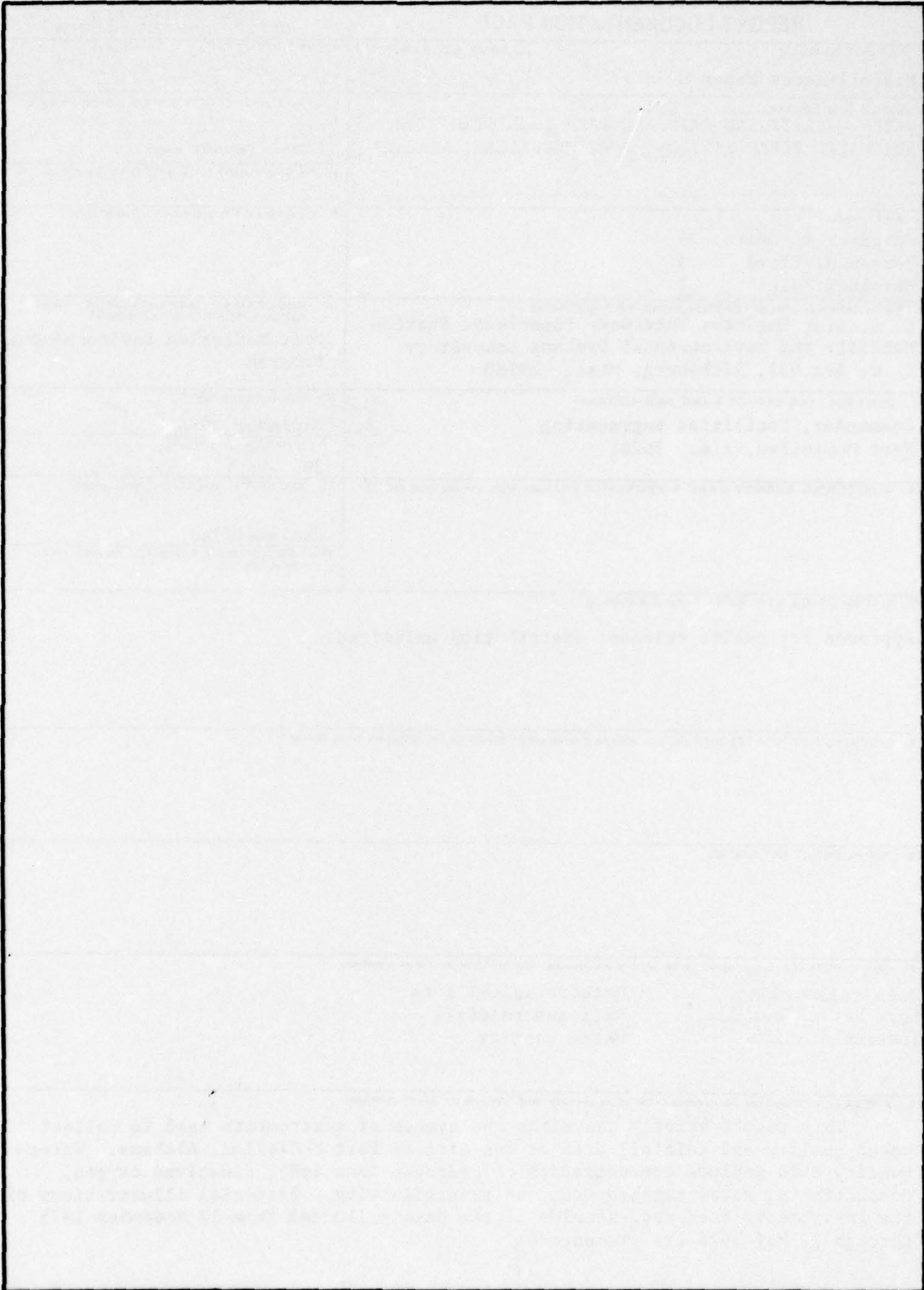
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Preface

The study reported herein was funded by Facilities Engineering, Fort McClellan, Alabama. The Program Manager at Fort McClellan was Mr. Phil Huber, Environmental Office. The work was performed during the period 12 November 1975 through 27 May 1976 by personnel of the Environmental Simulation Branch (ESB), Environmental Systems Division (ESD), Mobility and Environmental Systems Laboratory (MESL), U. S. Army Engineer Waterways Experiment Station (WES), under the direct supervision of Messrs. J. K. Stoll, Chief, ESB, and H. W. West, Project Manager. The study was under the general supervision of Messrs. W. G. Shockley, Chief, MESL, and B. O. Benn, Chief, ESD. Mr. H. M. Floyd, Instrumentation Services Division, WES, was responsible for the field instrumentation, and Ms. M. H. Smith, ESB, was responsible for processing the field data into engineering units. Mr. Charles E. Mayo, Fort McClellan, assisted the WES in the maintenance of the field instrumentation. The report was prepared by Ms. Smith, and Messrs. Floyd and West.

The automated system deployed at Fort McClellan and discussed herein for collecting, processing, and displaying environmental baseline data was developed under Department of the Army Project 4A762720A896, "Environmental Quality for Construction and Operation of Military Facilities," Task 01, "Environmental Quality Management for Military Facilities," Work Unit 006, "Methodology for Characterization of Military Installations Environmental Baselines," sponsored by the Directorate of Military Construction, Office, Chief of Engineers, U. S. Army.

COL G. H. Hilt, CE, and COL J. L. Cannon, CE, were Directors of the WES during this study and the preparation of the report. Mr. F. R. Brown was Technical Director.

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Conversion Factors, Metric (SI) Units to U. S. Customary Units
of Measurement

Metric (SI) units of measurement in this report can be converted to U. S. customary units as follows:

<u>Multiply</u>	<u>By</u>	<u>To Obtain</u>
millimetres	0.03937007	inches
centimetres	0.3937007	inches
metres	3.280839	feet
kilograms	2.204622	pounds (mass)
milligrams per litre	6.242797×10^{-5}	pounds (mass) per cubic foot
	1.0	parts per million
grams per litre	0.06242797	pounds (mass) per cubic foot
Celsius degrees	1.8	Fahrenheit degrees*

* To obtain Fahrenheit (F) temperature readings from Celsius (C) readings, use the following formula: $F = 1.8(C) + 32$.

WATER-QUALITY AND RAINFALL DATA COLLECTED WITH AUTOMATED FIELD
STATION, FORT MCCLELLAN, ALABAMA

Background

1. Under Army Regulation 200-1, the Department of the Army recognizes its obligation to act responsibly in the management of natural resources under its jurisdiction. In accordance with this regulation, the Post Engineer at Fort McClellan, Alabama, has initiated plans for developing a long-range program to improve management of the installation's natural resources and maintenance of environmental quality. Fort McClellan requested that the U. S. Army Engineer Waterways Experiment Station (WES) provide assistance in acquiring water-quality and rainfall data. This work constitutes an initial phase in upgrading data acquisition procedures for the long-range environmental management program.

2. The WES has developed and field tested a reliable, instrumented environmental data system to: (a) sense and record on magnetic cassette tape selected environmental data on-site, in real time, at sampling rates selected by the user; (b) sort and store the recorded data for computer processing and retrieval; and (c) display the recorded data in tabular or graphic formats specified by the user. To a large extent, the system operates automatically and substantially reduces the costs and errors incurred in manual data recording and handling. This system was used to monitor and record data on water quality and rainfall at Fort McClellan, Alabama.

Purpose

3. This report briefly describes the system of instruments used by the WES to collect water-quality and rainfall data at one site at Fort McClellan, Alabama, from 12 November 1975 through 27 May 1976, and presents examples of the data that were collected.

Location and Description of the Automated Field Station

4. An automated field station was installed at Fort McClellan on Cane Creek at military coordinates 104323 (Figure 1). The station was composed of one 32-channel Lockheed Electronics Corporation (LEC) 101R digital recorder^{*} interfaced with rainfall, transmissivity, pH, conductivity, dissolved oxygen, and water temperature sensors. Figure 2 shows the field recorder and sensors, and Figure 3 presents the display and recording instrumentation as installed at the site.

5. The recorder has been designed to meet the need for an unattended data gathering facility capable of measuring environmental parameters (and engineering parameters) and recording the data on magnetic (cassette) tape at any of 10 different time intervals. The recorder can accept, condition, and record data from a wide variety of sensors to provide digital, impedance, or low-level voltaic output. It is battery- and solar-powered and is capable of recording data from as many as 31 sensors over a relatively long time, dependent upon the number of sensors and sampling intervals selected. A unique design feature of the recorder is its low standby power consumption. Low power consumption is achieved by deactivation of all circuits, except essential control circuits, during periods when no information is being processed and recorded. When the preselected sampling time occurs, the recorder is automatically activated while the data from all the sensors are being conditioned and recorded, then deactivated upon completion of the process. Since the time required for this process is very short compared with time between sampling periods, the average power consumption is held to a minimum. The recorder's solar panel provides the capability for recharging the battery over long data collection periods.

* For a detailed discussion of the LEC 101R field recorder and selected sensors, see H. W. West and H. M. Floyd, "An Automated System for Collecting, Processing, and Displaying Environmental Baseline Data," Technical Report M-76-11, Nov 1976, U. S. Army Engineer Waterways Experiment Station, CE, Vicksburg, Miss.

Descriptions of Sensors

6. Environmental data were collected using two different sampling intervals (30- and 60-min) from 12 November 1975 through 27 May 1976. Six sensors were used to measure rainfall and the following water-quality data:

- a. Concentration of hydrogen ions (pH).
- b. Dissolved oxygen.
- c. Conductivity.
- d. Water temperature.
- e. Transmissivity.

These sensors with appropriate mathematical conversions of the field data to engineering units are described in the following paragraphs.

Rainfall sensor

7. Rainfall was measured continuously with a Weather Measure* Model P-501 rain gage. All internal parts are aluminum, chrome-plated brass, or stainless steel. The rain gage has a 20.3-cm**-diam orifice protected by a heavy brass ring and has a tipping-bucket mechanism coupled to a mercury switch to produce an output. The tipping-bucket mechanism (Figure 4) uses balanced polyethylene buckets suspended on stainless steel pivots.

8. As rainfall enters the orifice, it is drained to the gage's interior into one of the two buckets in the tipping mechanism. When one bucket is full, the weight of the water causes it to tip and the second bucket swings into place beneath the entry funnel. As each bucket tips, the water drains out through the base of the gage where it can be accumulated and analyzed, if desired. The tipping action causes a mercury switch beneath the tipping-bucket mechanism to close momentarily. The gage is calibrated such that one switch closure is produced for each 0.254 mm of rainfall. The number of switch closures received during the interrogation interval is counted, and the total

* Weather Measure Corporation, Sacramento, California.

** A table of factors for converting metric (SI) units of measurement to U. S. customary units is given on page 4.

is transferred to the cassette tape. Later, appropriate software is used to calculate the total rainfall (in mm) for the interrogation interval. The conversion is:

$$\text{Rainfall} = \text{number of switch closures (counts) for the specified recording period} \times 0.254$$

Water-quality sensors

9. A Martek Mark V (Figure 5) sensor package containing pH, conductivity, dissolved oxygen, and water temperature sensors was used at Fort McClellan. These four sensors are discussed in detail in the following paragraphs.

10. Concentration of hydrogen ions (pH). The definition of "pH" is the negative logarithm of the hydrogen ion concentration in gram-ions per litre. The pH scale varies from 0 to 14 and is based on the ionization of pure water. It is measured by sensing the potential difference between a reference electrode and a glass pH electrode. The value of this potential difference, or signal, at pH 7 (the neutral condition) lies between -40 and +40 mV, the actual value depending on the individual characteristics of the particular glass electrode used. The magnitude of the change in potential difference per unit of pH at 25°C is 59.2 mV. For accuracy, the pH measuring system is temperature compensated; this is accomplished by a temperature-sensitive resistor or thermistor included in the pH amplifier circuit.

11. The following are the characteristics of the Martek Mark V pH sensor:

- a. Range, pH: 0-14.
- b. Calibrated accuracy, pH: ± 0.03 .
- c. Resolution, pH: 0.01.
- d. Operating temperature range, °C: 0-50.
- e. Output, mV: 0-1000.

12. Signal conditioning was set up so that the output range is 0-1000 mV recorded on the cassette tape. The tape value is converted to pH by the following computation.

$$\text{pH} = \text{recorded value} \times 0.014$$

13. Dissolved oxygen. A Martek Mark V polarographic sensor was used to collect data on dissolved oxygen. It consists of a silver anode and a gold cathode enclosed in a polyvinylchloride housing. A solution of potassium chloride is the electrolytic agent. A Teflon membrane, permeable to oxygen, is placed over the cathode. A voltage applied across the two electrodes results in a current flow that is proportional to the partial pressure of oxygen at the probe tip, and the sensor produces an output signal as long as the electrolyte is exposed to oxygen. A pressure-equalizing diaphragm, on the side of the probe housing, flexes as necessary to provide pressure equalization across the membrane.

14. A separate underwater temperature probe is used to measure water temperature for calibrating oxygen partial pressure values in milligrams per litre of water. It forms part of an automatic temperature-compensation circuit, which corrects dissolved oxygen readings for both temperature effects on the oxygen probe membrane permeability and variation in oxygen solubility in natural waters as a function of temperature.

15. Characteristics of the Martek Mark V dissolved oxygen sensor are:

- a. Range, mg/l: 0-20.
- b. Calibrated accuracy, mg/l: +0.05.
- c. Resolution, mg/l: 0.01.
- d. Operating range °C: -30 to +70.
- e. Output, mV: 0-1000.

16. Signal conditioning was set up so that it produces a 0- to 1000-mV output for 0- to full-scale input from the dissolved oxygen

sensor. The recorded value converted to dissolved oxygen in mg/l is

$$\text{Dissolved oxygen} = \text{recorded value} \times 0.02$$

17. Water conductivity. Electrolytic conductivity of solutions is a nonspecific measurement of the ions in a solution. The values obtained are a function of the number of ions, their electrical charge, their rate of movement, and temperature. Moreover, the magnitude of the temperature effects is different for the different ions and changes with concentration. Finally, it should be pointed out that the conductivity is not a linear function of the number of ions in the solution. For example, the use of electrical conductivity to obtain the exact concentration of salts in solution is restricted to solutions of known compositions, such as seawater. When seawater is diluted by fresh water, such as in an estuary, errors caused by changes in salt composition and dilution will result in less than accurate results. The use of conductivity data in very dilute solutions, as in fresh water to obtain concentration of dissolved salts, is an estimate at best. This measurement is based on a variation of Ohm's Law:

$$\text{Conductance in mmmhos} = \frac{\text{current}}{\text{voltage}}$$

Thus, if the voltage drop across two electrodes is kept constant, conductance is directly proportional to the current through the cell. This is the principle employed in the Mark V conductivity sensor.

18. The conductivity-measuring circuit in the Mark V unit consists of a very closely regulated 1000-Hz sine wave generator, which feeds its output (0.5 V) to the conductivity cell. The current passing through the cell is then fed to a current-to-voltage converter, where it is changed to an a-c voltage proportional to conductance. This a-c voltage is then converted to a pulsating d-c voltage by a phase detector, and the resulting direct current can be read on a

display meter supplied with the Mark V and, by suitable signal conditioning, can be simultaneously output to the field station. Since the phase detector is sensitive only to that part of the signal that is in phase with the applied voltage, the overall circuit "sees" only the cell resistance, not the cable capacitance, which would cause large errors. The conductivity cell has large nickel electrodes, which are coated with platinum black to increase the surface area, reducing resistive effects at the electrode surfaces.

19. Characteristics of the Martek Mark V conductivity sensor appear below. (Conductivity is recorded in μmhos (mmmmhos).)

- a. Range, mmmhos/cm: 0-1000.
- b. Calibrated accuracy: ± 5.0 mmmhos/cm.
- c. Resolution: 1.0 mmmhos/cm.

20. Signal conditioning was set to produce a recorded output of 0-1.0 V, analogous to 0- to full-scale sensor output. Therefore, the recorded value equals conductivity in mmmhos/cm, and no conversion is required.

21. Water temperature. Water temperature was measured with a thermolinear array in the Martek Mark V package (Figure 5). The output voltage of this sensor is linearly proportional to temperature as long as the current through the sensor is constant. This constant current is supplied by the sensor amplifier.

22. Characteristics of the Martek Mark V temperature sensor are listed below.

- a. Range, $^{\circ}\text{C}$: -5 to +45.
- b. Calibrated accuracy, $^{\circ}\text{C}$: +0.1.
- c. Resolution, $^{\circ}\text{C}$: 0.01.

23. Signal conditioning was set up to produce a range of 0-1.0 V recorded on the magnetic tape for 0- to full-scale output of the sensor. The conversion to water temperature in $^{\circ}\text{C}$ is

$$\text{Water temperature} = \text{recorded value} \times 0.045$$

24. Water transmissivity. The Martek Model XMS transmissometer (Figure 6) is a portable instrument specifically designed for optimum underwater measurements of generally turbid waters such as are found in rivers, lakes, harbors, and estuaries. It measures turbidity by determining the percent transmission of a light beam through a known path length (1/4 m) in the water. The transmissometer provides an accurate and reliable means of determining one of the fundamental optical properties of water, the beam attenuation coefficient alpha, a determinant of water clarity. It is very accurate, ± 1.0 percent over a wide alpha-measurement range, and is ideally suited for water with a range from 25 to 0.01 percent transmittance (T) per metre. The useful range extends down to 10^{-6} percent T/m.

25. The Martek Model XMS transmissometer consists of a solid-state electronic readout module with an a-c/d-c power supply, up to 100 m of multiconductor underwater cable with molded waterproof connectors, and an underwater folded optical path sensor with associated electronics. The readout module is housed in a compact, steel carrying case with detachable lid and canted control panel to permit moisture runoff and efficient viewing angle. Digital readout of the light transmittance measurement can be obtained instantaneously on the high-resolution, 1-percent mirrored panel meter using scales of 0-10, 0-25, and 0-100 percent transmittance. Manual readings with the display module provide additional data for comparison to the data being recorded on cassette tape.

26. The percent transmittance obtained with the sensor is in units of percent T per cell-path length. For a 1-m cell-path sensor, the unit measurement is percent T per metre and for the 1/4-m cell-path sensor, the measurement is percent T per 1/4 m. In essence, the percent transmittance measurements are a function of the cell-path length; the 1/4-m cell path provides higher transmittance values than the 1-m cell path. Inasmuch as the scientific literature reports, and customary practice is to use, readings in percent T per metre, it is desirable to convert the percent T per 1/4 m to percent T per metre to obtain ready comparisons with reference data.

27. The relation between $T(1/4)$ (transmittance per 1/4 m) and $T(1)$ (transmittance per metre) is

$$T(1) = \left[T\left(\frac{1}{4}\right) \right]^4$$

where transmittance is expressed in absolute units rather than in percent.

28. The sensor contains a specifically designed optical system, a projection lamp, a receiver photocell, and operational amplifiers to provide a high-level signal proportional to receiver flux.

29. Characteristics of the Model XMS transmissiometer are:

- a. Range: 0-10, 0-25, and 0-100 percent T.
- b. Ambient light interference: negligible.
- c. Operating temperature: -2° to $+40^{\circ}\text{C}$.
- d. Operating depth: 0-100 m.
- e. Overall system accuracy: ± 1.0 percent.
- f. Operating power: Regulated self-contained; 105- to 125-V (a-c) (50/60 Hz) or 12-V (d-c) primary input. AC was used at Fort McClellan.
- g. Dimensions: approximately 20-cm-diam by 50 cm long.
- h. Weight: approximately 10.9 kg.

30. Signal conditioning was set up to yield an output of 0-1.0 V corresponding to the sensor's 0- to 0.5-V output signal. The algorithms converting sensor output to percent transmittance over 1/4-m and 1-m paths, respectively, are

$$\begin{aligned}\text{Percent } T(1/4\text{-m}) &= \text{recorded value} \times 0.001 \times 100 \\ &= \text{recorded value} \times 0.1\end{aligned}$$

$$\text{Percent } T(1\text{-m}) = (\text{recorded value} \times 0.1)^4 \times 100$$

where

0.001 converts output voltage to transmittance in absolute units
100 converts absolute units to percent

Field Data Collected

31. The environmental data collected through May 1976 with the WES system of instruments at Fort McClellan were recorded on nine different cassette tapes as follows:

<u>Cassette Tape No.</u>	<u>Data Collection Period</u>	<u>Sampling Interval, min</u>
1	12 Nov 75 - 26 Nov 75	60
2	26 Nov 75 - 19 Dec 75	60
4	9 Jan 76 - 10 Feb 76	60
5	11 Feb 76 - 4 Mar 76	60
7	18 Mar 76 - 15 Apr 76	30
8	15 Apr 76 - 5 May 76	60
9	5 May 76 - 27 May 76	60

32. The cassette tapes were picked up at the end of each data collection period and taken to the WES for data translation, processing, and display. The processing and display were accomplished through the use of a software package using a 16k-memory PDP-15/30 Digital Equipment Corporation Computer. The rather large amounts of data collected at the Fort McClellan site were forwarded to Fort McClellan periodically during the data collection effort. They are not included in this report but are on file at both Fort McClellan and the WES. A copy of the data is available for loan and may be obtained by writing the U. S. Army Engineer Waterways Experiment Station, ATTN: WESFE, Vicksburg, Miss. 39180.

33. The environmental data collected at Fort McClellan are output in tabular and graphic formats as described below.

- a. Tabular data. Tabulations are produced for all sensors for each 30- or 60-min sampling interval used. One line of data in the computer printout represents one sampling interval of data collection. Table 1 is an excerpt (16-27 February 1976) from the tabular data for the collection period 11 February through 4 March 1976.

- b. Graphic data. The data are also produced in two different graphic formats. The first is a line plot (Figure 7) or bar graph (Figure 8) that depicts the individual parameter values for each respective sampling interval. Each graph contains data for a period of 7 days. The second format is a line plot (Figure 9) that shows the maximum, average, and minimum for the parameter during the collection period at each time interval of a day. For example, the maximum, average, and minimum parameter values for conductivity during the period 11 February through 4 March 1976 are included in Figure 9. The maximum and minimum water conductivity measured at 0920 were 134.00 and 80.00 mmhos/cm, respectively; the calculated average was 112.00 mmhos/cm.

Table 1

Excerpt of Tabular Data

CANE CREEK WATER QUALITY STATION
MILITARY COORDINATES = 014323
FORT MCCLELLAN, ALABAMA

RECORD PERIOD: 11 FEB - 04 MAR 1976

SAMPLE*		* WATER *		* CONDUC-*		* DISSOLVED*		* TRANSMIS-*	
DATE	TIME *	TEMPER-	ATURE *	TIVITY *	OXYGEN *	SIVITY *	SIVITY *	PERCENT *	PERCENT *
DA MO YR	HR MN*	RAIN	MM	DEG.C	MMMHOS/CM*	MG/1	PH	1M-PATH	1/4M PATH*
(SENSOR NO.)		1	2	3	4	5	6	6	6
16	2 76								
	20*20	0.00	15.84	140.00	6.78	7.59	0.011	10.3	
	21*20	0.00	15.57	137.00	6.84	7.49	0.056	15.4	
	22*20	0.00	15.39	139.00	6.84	7.46	0.014	10.9	
	23*20	0.00	15.08	134.00	6.92	7.42	0.058	15.5	
17	2 76								
	0*20	0.00	14.94	130.00	7.00	7.39	0.157	19.9	
	1*20	0.00	14.89	128.00	7.00	7.38	0.239	22.1	
	2*20	0.00	14.76	128.00	7.06	7.39	0.280	23.0	
	3*20	0.00	14.71	127.00	7.06	7.42	0.285	23.1	
	4*20	0.00	14.54	126.00	7.10	7.41	0.270	22.8	
	5*20	0.00	14.62	132.00	6.98	7.39	0.053	15.2	
	6*20	0.00	14.62	138.00	6.98	7.50	0.011	10.3	
	7*20	0.00	14.67	139.00	7.16	7.41	0.003	7.4	
	8*20	0.00	14.89	136.00	8.02	7.60	0.005	8.3	
	9*20	0.00	15.12	134.00	8.50	7.84	0.078	16.7	
	10*20	0.00	15.43	134.00	8.62	8.12	0.142	19.4	
	11*20	0.00	16.07	137.00	8.84	8.39	0.184	20.7	
	12*20	0.00	16.78	142.00	9.04	8.61	0.270	22.8	
	13*20	0.00	18.00	150.00	8.84	8.75	0.256	22.5	
	14*20	0.00	18.40	153.00	8.70	8.79	0.001	6.2	
	15*20	0.00	18.22	148.00	8.34	8.81	0.210	21.4	
	16*20	0.00	17.73	143.00	7.66	8.69	0.222	21.7	
	17*20	0.00	17.32	140.00	6.96	8.47	0.218	21.6	
	18*20	0.00	16.92	138.00	6.46	8.11	0.194	21.0	
	19*20	0.00	16.65	138.00	6.38	7.80	0.163	20.1	
	20*20	0.00	16.34	136.00	6.36	7.59	0.148	19.6	
	21*20	0.00	16.02	135.00	6.44	7.50	0.002	6.5	
	22*20	0.00	15.75	134.00	6.48	7.46	0.128	18.9	
	23*20	0.00	15.80	134.00	6.46	7.45	0.122	18.7	
18	2 76								
	0*20	0.00	15.75	134.00	6.46	7.42	0.120	18.6	
	1*20	0.00	15.70	134.00	6.46	7.42	0.115	18.4	
	2*20	0.00	15.52	133.00	6.50	7.41	0.110	18.2	
	3*20	0.00	15.35	131.00	6.60	7.41	0.110	18.2	
	4*20	0.00	15.35	123.00	6.58	7.42	0.100	17.8	
	5*20	3.56	14.98	112.00	6.76	7.42	0.051	15.0	
	6*20	0.76	14.94	113.00	6.68	7.42	0.002	6.9	
	7*20	3.30	14.85	114.00	6.72	7.49	0.002	6.4	
	8*20	1.52	14.67	112.00	6.86	7.45	0.001	6.1	
	9*20	0.00	14.85	114.00	7.14	7.56	0.001	6.1	
	10*20	0.00	15.08	119.00	6.96	7.49	0.001	6.1	
	11*20	0.00	15.62	123.00	6.94	7.57	0.001	6.2	
	12*20	0.25	16.07	123.00	7.20	7.62	0.001	6.1	
	13*20	0.00	16.92	134.00	7.34	7.81	0.002	6.3	

(Continued)

(Sheet 1 of 6)

Table 1 (Continued)

CANE CREEK WATER QUALITY STATION
MILITARY COORDINATES = 014323
FORT MCCLELLAN, ALABAMA

RECORD PERIOD: 11 FEB - 04 MAR 1976

DATE		SAMPLE*	* WATER *	* CONDUC-	* DISSOLVED*	* TRANSMIS-	* TRANSMIS-
DA MO YR	HR MN	TIME *	* TEMPER-	* TIVITY *	* OXYGEN *	* SIVITY *	* SIVITY *
		RAIN	* ATURE *	* TIVITY *	* OXYGEN *	* PERCENT *	* PERCENT *
		MM	* DEG.C	* MMHOS/CM*	MG/L	* 1M-PATH	* 1/4M PATH*
(SENSOR NO.)							
18	2	76					
		14*20	0.00	17.14	134.00	7.26	7.88
		15*20	0.00	16.97	132.00	7.14	7.98
		16*20	0.00	16.47	126.00	7.04	7.99
		17*20	0.00	15.80	119.00	6.52	7.76
		18*20	0.00	15.30	116.00	6.26	7.49
		19*20	0.00	14.89	113.00	6.30	7.38
		20*20	0.00	14.54	111.00	6.36	7.35
		21*20	0.00	14.13	108.00	6.46	7.29
		22*20	0.00	13.72	106.00	6.58	7.27
		23*20	0.00	13.28	104.00	6.68	7.24
19	2	76					
		0*20	0.00	12.87	103.00	6.76	7.21
		1*20	0.00	12.42	102.00	6.82	7.21
		2*20	0.00	12.01	101.00	6.96	7.20
		3*20	0.00	11.61	100.00	7.06	7.22
		4*20	0.00	11.25	100.00	7.12	7.22
		5*20	0.00	10.89	99.00	7.20	7.22
		6*20	0.00	10.58	98.00	7.30	7.25
		7*20	0.00	10.39	97.00	7.74	7.29
		8*20	0.00	10.98	101.00	8.36	7.48
		9*20	0.00	11.97	115.00	8.60	7.71
		10*20	0.00	13.10	127.00	8.58	7.95
		11*20	0.00	14.36	136.00	8.46	8.16
		12*20	0.00	15.62	142.00	8.30	8.32
		13*20	0.00	16.38	145.00	8.14	8.44
		14*20	0.00	16.74	146.00	7.98	8.50
		15*20	0.00	16.61	144.00	7.80	8.48
		16*20	0.00	15.93	138.00	7.50	8.46
		17*20	0.00	15.08	130.00	6.86	8.22
		18*20	0.00	14.49	122.00	6.38	7.85
		19*20	0.00	14.04	119.00	6.34	7.52
		20*20	0.00	13.59	116.00	6.34	7.38
		21*20	0.00	13.18	114.00	6.40	7.28
		22*20	0.00	12.73	113.00	6.46	7.24
		23*20	0.00	12.29	111.00	6.52	7.21
20	2	76					
		0*20	0.00	11.88	110.00	6.58	7.17
		1*20	0.00	11.47	108.00	6.68	7.17
		2*20	0.00	11.16	107.00	6.78	7.17
		3*20	0.00	10.80	106.00	6.84	7.20
		4*20	0.00	10.44	105.00	6.96	7.20
		5*20	0.00	10.17	103.00	7.02	7.20
		6*20	0.00	9.90	103.00	7.10	7.22
		7*20	0.00	9.86	101.00	7.54	7.28

(Continued)

(Sheet 2 of 6)

Table 1 (Continued)

CANE CREEK WATER QUALITY STATION
MILITARY COORDINATES = 014323
FORT MCCLELLAN, ALABAMA

RECORD PERIOD: 11 FEB - 04 MAR 1976

DATE		SAMPLE	* WATER *		* CONDUCTIVITY *		* DISSOLVED OXYGEN *		* TRANSMISSIVITY *		* TRANSMISSIVITY *	
DA	MO	YR	HR	MIN	TEMPERATURE	CONDUCTIVITY	DISSOLVED OXYGEN	PH	PERCENT	PERCENT	PERCENT	PERCENT
MM	MM	MM	MM	MM	DEG C	MMMHOS/CM	MG/L	PH	1M-PATH	1/4M PATH	1/4M PATH	1/4M PATH
(SENSOR NO.)		1	2	3	4	5	6	7	8	9	10	11
20	2	76	8	20	0.00	10.48	106.00	8.12	7.41	0.004	7.7	
			9	20	0.00	11.47	119.00	8.44	7.67	0.003	7.6	
			10	20	0.00	12.69	132.00	8.42	7.90	0.004	7.9	
			11	20	0.00	14.22	140.00	8.36	8.09	0.005	8.2	
			12	20	0.00	15.52	147.00	8.14	8.26	0.002	6.5	
			13	20	0.00	16.43	151.00	7.90	8.41	0.003	7.5	
			14	20	0.00	16.87	152.00	7.66	8.46	0.004	7.9	
			15	20	0.00	16.74	149.00	7.52	8.48	0.003	7.2	
			16	20	0.00	15.97	141.00	7.18	8.46	0.003	7.1	
			17	20	0.00	15.35	134.00	6.56	8.26	0.002	6.9	
			18	20	0.00	14.71	128.00	6.02	7.87	0.002	6.9	
			19	20	0.00	14.31	126.00	5.96	7.52	0.002	6.8	
			20	20	0.00	14.09	125.00	5.96	7.35	0.002	6.7	
			21	20	0.00	13.82	125.00	5.96	7.27	0.002	6.6	
			22	20	0.00	13.55	124.00	6.00	7.24	0.002	6.5	
			23	20	0.00	13.28	123.00	6.02	7.24	0.002	6.7	
21	2	76	0	20	0.00	12.96	122.00	6.10	7.20	0.002	6.6	
			1	20	0.00	12.78	121.00	6.08	7.17	0.002	6.7	
			2	20	0.00	12.60	120.00	6.14	7.20	0.002	6.7	
			3	20	0.00	12.29	119.00	6.22	7.20	0.002	6.6	
			4	20	0.00	11.97	118.00	6.26	7.20	0.002	6.6	
			5	20	0.00	11.88	117.00	6.32	7.21	0.002	6.4	
			6	20	0.00	11.79	117.00	6.38	7.21	0.002	6.5	
			7	20	0.00	11.97	117.00	6.82	7.24	0.002	6.8	
			8	20	0.00	12.51	119.00	7.54	7.45	0.002	6.9	
			9	20	0.00	13.32	123.00	7.72	7.66	0.003	7.1	
			10	20	0.00	15.03	140.00	7.82	7.98	0.003	7.4	
			11	20	0.00	16.07	144.00	7.70	8.18	0.003	7.1	
			12	20	0.00	16.47	144.00	7.58	8.32	0.002	6.9	
			13	20	0.00	16.61	143.00	7.52	8.41	0.002	6.9	
			14	20	0.00	16.56	139.00	7.00	8.40	0.002	6.7	
			15	20	3.56	16.20	115.00	6.18	8.23	0.002	6.6	
			16	20	9.14	16.07	112.00	5.70	7.81	0.001	6.2	
			17	20	1.27	15.93	96.00	5.60	7.55	0.001	6.2	
			18	20	0.00	15.62	88.00	5.50	7.38	0.001	6.0	
			19	20	0.00	15.30	88.00	5.40	7.25	0.001	6.1	
			20	20	0.00	15.12	87.00	5.30	7.20	0.002	6.3	
			21	20	0.00	14.94	87.00	5.26	7.15	0.001	6.1	
			22	20	0.25	14.85	87.00	5.22	7.11	0.001	6.2	
			23	20	0.25	14.76	86.00	5.24	7.13	0.001	6.1	
22	2	76	0	20	0.00	14.58	86.00	5.26	7.11	0.001	6.0	
			1	20	0.00	14.44	87.00	5.26	7.10	0.001	6.2	

(Continued)

(Sheet 3 of 6)

Table 1 (Continued)

CANE CREEK WATER QUALITY STATION
MILITARY COORDINATES = 014323
FORT MCCLELLAN, ALABAMA

RECORD PERIOD: 11 FEB - 04 MAR 1976

SAMPLE*				* WATER *	* CONDUC-	* DISSOLVED*	* TRANSMIS-	* TRANSMIS-
DATE	TIME			* TEMPER-	* TIVITY	* OXYGEN *	* SIVITY	* SIVITY *
DA MO YR	HR MM	RAIN		* ATURE	* CMHOS/CM*	* MG/1	* PERCENT	* PERCENT *
-----*	-----*	MM		* DEG.C			* 1M-PATH	*1/4M PATH*
(SENSOR NO.)								
22	2 76							
	2*20	0.00		13.99	89.00	5.32	7.13	0.001
	3*20	0.00		13.63	89.00	5.40	7.11	0.001
	4*20	0.00		13.14	89.00	5.50	7.14	0.001
	5*20	0.00		12.51	87.00	5.62	7.10	0.001
	6*20	0.00		12.06	87.00	5.70	7.11	0.001
	7*20	0.00		11.70	86.00	5.96	7.14	0.002
	8*20	0.00		11.70	86.00	6.40	7.22	0.001
	9*20	0.00		11.70	86.00	6.60	7.34	0.002
	10*20	0.00		11.43	86.00	6.58	7.38	0.002
	11*20	0.00		11.43	87.00	6.70	7.45	0.002
	12*20	0.00		11.47	87.00	6.76	7.50	0.002
	13*20	0.00		11.25	87.00	6.70	7.55	0.002
	14*20	0.00		11.12	87.00	6.64	7.56	0.002
	15*20	0.00		10.98	86.00	6.78	7.57	0.002
	16*20	0.00		10.75	86.00	6.64	7.57	0.002
	17*20	0.00		10.39	85.00	6.52	7.52	0.002
	18*20	0.00		10.08	84.00	6.28	7.41	0.001
	19*20	0.00		9.76	82.00	6.24	7.31	0.001
	20*20	0.00		9.54	82.00	6.28	7.27	0.002
	21*20	0.00		9.27	81.00	6.32	7.25	0.002
	22*20	0.00		9.00	81.00	6.34	7.24	0.001
	23*20	0.00		8.73	80.00	6.40	7.25	0.001
23	2 76							
	0*20	0.00		8.46	79.00	6.46	7.22	0.002
	1*20	0.00		8.19	78.00	6.52	7.24	0.001
	2*20	0.00		7.92	77.00	6.58	7.25	0.001
	3*20	0.00		7.65	76.00	6.68	7.25	0.001
	4*20	0.00		7.42	75.00	6.72	7.25	0.001
	5*20	0.00		7.11	75.00	6.78	7.24	0.001
	6*20	0.00		6.98	75.00	6.82	7.25	0.001
	7*20	0.00		6.88	72.00	7.18	7.28	0.002
	8*20	0.00		7.47	73.00	7.44	7.38	0.002
	9*20	0.00		8.41	80.00	7.48	7.53	0.002
	10*20	0.00		9.54	89.00	7.36	7.64	0.002
	11*20	0.00		10.89	95.00	7.16	7.76	0.002
	12*20	0.00		12.15	100.00	6.96	7.88	0.002
	13*20	0.00		12.87	103.00	6.82	7.95	0.002
	14*20	0.00		13.10	104.00	6.66	7.98	0.002
	15*20	0.00		13.00	103.00	6.62	8.02	0.001
	16*20	0.00		12.51	100.00	6.48	7.95	0.001
	17*20	0.00		11.79	93.00	6.16	7.87	0.001
	18*20	0.00		11.20	89.00	5.90	7.66	0.001
	19*20	0.00		10.75	87.00	5.92	7.50	0.001
	20*20	0.00		10.31	86.00	5.96	7.39	0.002

(Continued)

(Sheet 4 of 6)

Table 1 (Continued)

CANE CREEK WATER QUALITY STATION
MILITARY COORDINATES = 014323
FORT MCCLELLAN, ALABAMA

RECORD PERIOD: 11 FEB - 04 MAR 1976

DATE	SAMPLE*		* WATER *				* TRANSMIS-*	* TRANSMIS-*
DA MO YR	TIME *	RAIN	* TEMPER-*	* CONDC-*	* DISSOLVED*		* SIVITY *	* SIVITY *
	HR MN*		* ATURE *	* TIVITY *	* OXYGEN *		* PERCENT *	* PERCENT *
(SENSOR NO.)		MM	* DEG.C	* MMMHOS/CM*	MG/1	PH	* 1M-PATH	* 1/4M PATH*
23 2 76	21*20	0.00	9.90	84.00	6.04	7.34	0.002	6.3
	22*20	0.00	9.49	82.00	6.14	7.29	0.002	6.3
	23*20	0.00	9.13	81.00	6.20	7.29	0.002	6.3
24 2 76	0*20	0.00	8.78	81.00	6.30	7.27	0.001	6.2
	1*20	0.00	8.46	80.00	6.32	7.24	0.002	6.3
	2*20	0.00	8.19	80.00	6.40	7.24	0.002	6.3
	3*20	0.00	7.92	78.00	6.46	7.27	0.001	6.2
	4*20	0.00	7.61	78.00	6.58	7.22	0.001	6.2
	5*20	0.00	7.34	77.00	6.66	7.24	0.002	6.3
	6*20	0.00	7.20	77.00	6.64	7.27	0.001	6.2
	7*20	0.00	7.25	76.00	7.06	7.32	0.002	6.3
	8*20	0.00	7.83	78.00	7.30	7.45	0.002	6.6
	9*20	0.00	8.87	86.00	7.34	7.57	0.002	6.7
	10*20	0.00	10.17	96.00	7.22	7.73	0.002	6.8
	11*20	0.00	11.65	103.00	7.04	7.85	0.002	6.9
	12*20	0.00	12.96	108.00	6.74	7.92	0.002	6.6
	13*20	0.00	13.90	112.00	6.56	8.04	0.002	6.8
	14*20	0.00	14.44	115.00	6.44	8.12	0.002	6.6
	15*20	0.00	14.40	116.00	6.28	8.15	0.001	6.1
	16*20	0.00	13.95	113.00	6.06	8.09	0.001	6.0
	17*20	0.00	13.41	106.00	5.64	7.98	0.001	6.0
	18*20	0.00	12.83	100.00	5.38	7.76	0.001	6.0
	19*20	0.00	12.33	97.00	5.42	7.55	0.001	6.0
	20*20	0.00	11.88	95.00	5.44	7.42	0.001	6.0
	21*20	0.00	11.47	93.00	5.52	7.35	0.001	6.0
	22*20	0.00	10.98	91.00	5.58	7.32	0.001	6.2
	23*20	0.00	10.62	90.00	5.66	7.31	0.001	6.2
25 2 76	0*20	0.00	10.21	89.00	5.70	7.29	0.001	6.2
	1*20	0.00	9.86	88.00	5.76	7.28	0.002	6.3
	2*20	0.00	9.63	87.00	5.90	7.27	0.002	6.3
	3*20	0.00	9.45	86.00	5.92	7.28	0.002	6.3
	4*20	0.00	9.22	85.00	5.94	7.27	0.001	6.2
	5*20	0.00	9.00	84.00	6.02	7.27	0.002	6.3
	6*20	0.00	8.78	83.00	6.06	7.28	0.001	6.2
	7*20	0.00	8.78	82.00	6.52	7.32	0.002	6.4
	8*20	0.00	9.45	86.00	6.84	7.48	0.002	6.3
	9*20	0.00	10.48	97.00	6.90	7.66	0.002	6.6
	10*20	0.00	11.70	106.00	6.78	7.78	0.002	6.9
	11*20	0.00	13.23	112.00	6.62	7.91	0.002	7.0
	12*20	0.00	14.49	117.00	6.40	8.04	0.002	6.9
	13*20	0.00	15.35	121.00	6.26	8.16	0.002	6.8
	14*20	0.00	15.48	122.00	6.10	8.20	0.002	6.9

(Continued)

(Sheet 5 of 6)

Table 1 (Concluded)

CANE CREEK WATER QUALITY STATION
MILITARY COORDINATES = 014323
FORT MCCLELLAN, ALABAMA

RECORD PERIOD: 11 FEB - 04 MAR 1976

DATE		SAMPLE#	* WATER *		* CONDUC *		* DISSOLVED *		* TRANSMIS *		* TRANSMIS *	
DA	MO	YR	HR	NN#	* TEMPER *	* TIVITY *	* OXYGEN *		* SIVITY *	* SIVITY *	* PERCENT *	* PERCENT *
					* ATURE *	* MMHUS/LM *	* MG/1 *		* 1M-PATH *	* 1/4M PATH *		
					* DEG.C *							
(SENSOR NO.)			1	2	3	4	5	6	6			
25	2	76										
			15*20	0.00	15.62	122.00	5.98	8.27	0.002	6.3		
			16*20	0.00	15.08	118.00	5.82	8.29	0.001	6.2		
			17*20	0.00	14.26	111.00	5.46	8.20	0.001	6.1		
			18*20	0.00	13.72	106.00	5.08	7.97	0.001	6.1		
			19*20	0.00	13.32	104.00	5.04	7.71	0.001	6.0		
			20*20	0.00	13.10	103.00	5.08	7.55	0.001	6.1		
			21*20	0.00	12.83	102.00	5.12	7.46	0.001	5.9		
			22*20	0.00	12.42	101.00	5.14	7.38	0.001	6.1		
			23*20	0.00	12.24	99.00	5.16	7.32	0.001	6.1		
26	2	76										
			0*20	0.00	12.01	99.00	5.20	7.32	0.001	5.9		
			1*20	0.00	11.74	98.00	5.22	7.28	0.001	5.9		
			2*20	0.00	11.47	96.00	5.32	7.28	0.001	6.1		
			3*20	0.00	11.30	95.00	5.34	7.31	0.001	6.0		
			4*20	0.00	11.12	94.00	5.36	7.27	0.001	6.0		
			5*20	0.00	11.03	94.00	5.40	7.31	0.001	5.9		
			6*20	0.00	10.89	93.00	5.48	7.29	0.001	6.1		
			7*20	0.00	10.98	93.00	5.82	7.34	0.001	6.0		
			8*20	0.00	11.38	95.00	6.34	7.48	0.001	6.2		
			9*20	0.00	12.11	100.00	6.52	7.64	0.002	6.4		
			10*20	0.00	13.50	112.00	6.50	7.87	0.002	6.8		
			11*20	0.00	14.89	120.00	6.30	8.04	0.002	6.4		
			12*20	0.00	15.62	123.00	6.14	8.12	0.002	6.7		
			13*20	0.00	16.92	128.00	6.00	8.26	0.002	6.7		
			14*20	0.00	17.24	128.00	5.84	8.30	0.003	7.1		
			15*20	0.00	17.10	128.00	5.72	8.39	0.002	6.4		
			16*20	0.00	16.65	124.00	5.48	8.39	0.001	6.2		
			17*20	0.00	16.02	119.00	5.00	8.32	0.001	6.1		
			18*20	0.00	15.35	114.00	4.58	8.09	0.001	6.2		
			19*20	0.00	14.89	112.00	4.58	7.80	0.001	6.1		
			20*20	0.00	14.44	110.00	4.60	7.60	0.001	6.1		
			21*20	0.00	13.99	107.00	4.66	7.46	0.001	6.1		
			22*20	0.00	13.55	106.00	4.72	7.36	0.001	6.2		
			23*20	0.00	13.05	103.00	4.80	7.32	0.001	6.0		
27	2	76										
			0*20	0.00	12.60	102.00	4.86	7.31	0.001	6.1		
			1*20	0.00	12.15	100.00	4.90	7.28	0.001	6.1		
			2*20	0.00	11.70	98.00	4.98	7.25	0.001	6.2		
			3*20	0.00	11.25	97.00	5.10	7.24	0.002	6.3		
			4*20	0.00	10.89	95.00	5.22	7.25	0.001	6.2		
			5*20	0.00	10.48	94.00	5.30	7.25	0.001	6.2		
			6*20	0.00	10.08	92.00	5.40	7.24	0.001	6.2		
			7*20	0.00	10.04	91.00	5.90	7.32	0.001	6.2		
			8*20	0.00	10.71	95.00	6.40	7.49	0.001	6.2		



Figure 1. Location of automated field station, Cane Creek, Fort McClellan, Alabama



SENSORS

- DISSOLVED OXYGEN
- pH
- CONDUCTIVITY
- WATER TEMPERATURE
- TRANSMISSIVITY

a. Water-quality sensors



- RAINFALL

b. Rain gage and field recorder

Figure 2. Sensors and field recorder at the automated data collection station, Fort McClellan, Alabama

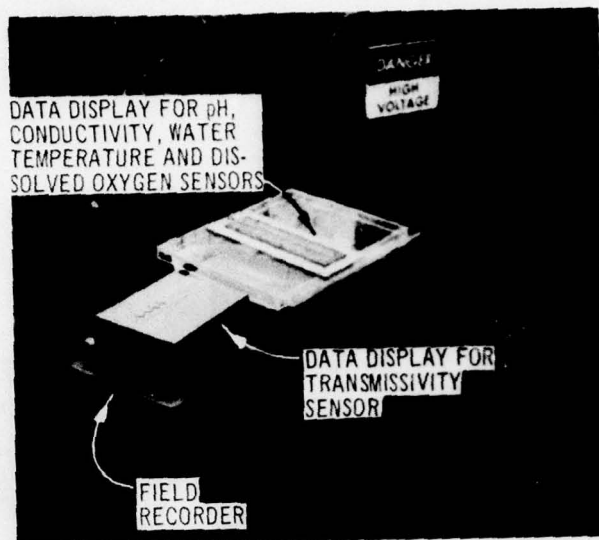


Figure 3. Display and recorder instrumentation at automated data collection station, Fort McClellan, Alabama

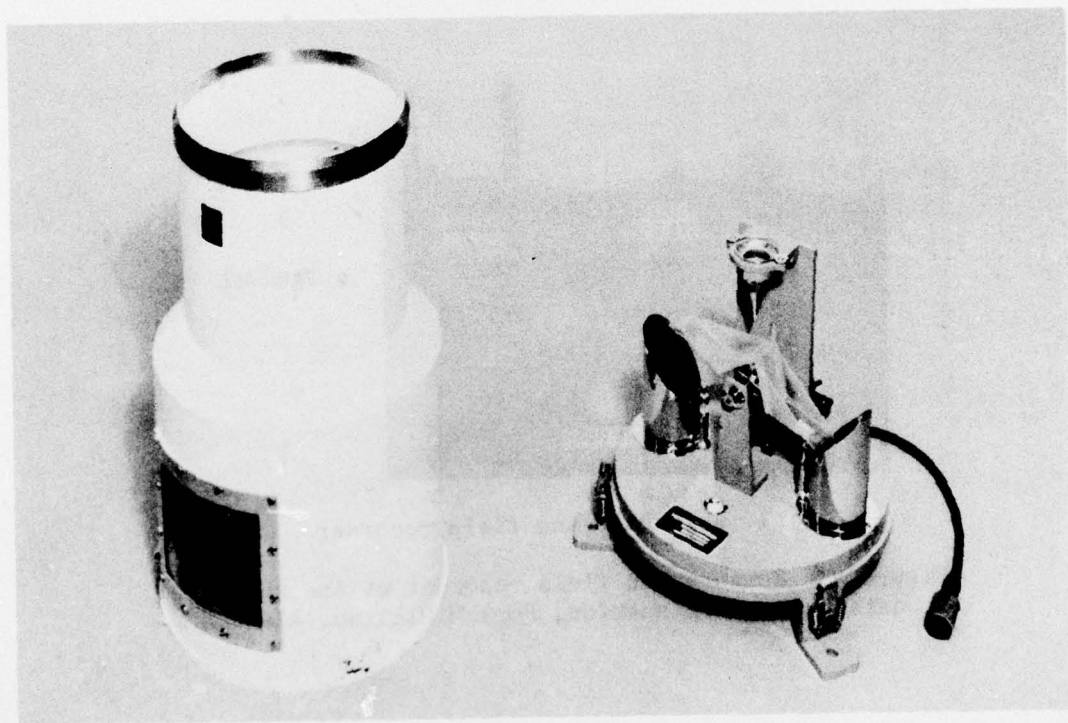


Figure 4. Interior of Weather Measure Model P-501 rain gage showing tipping-bucket mechanism

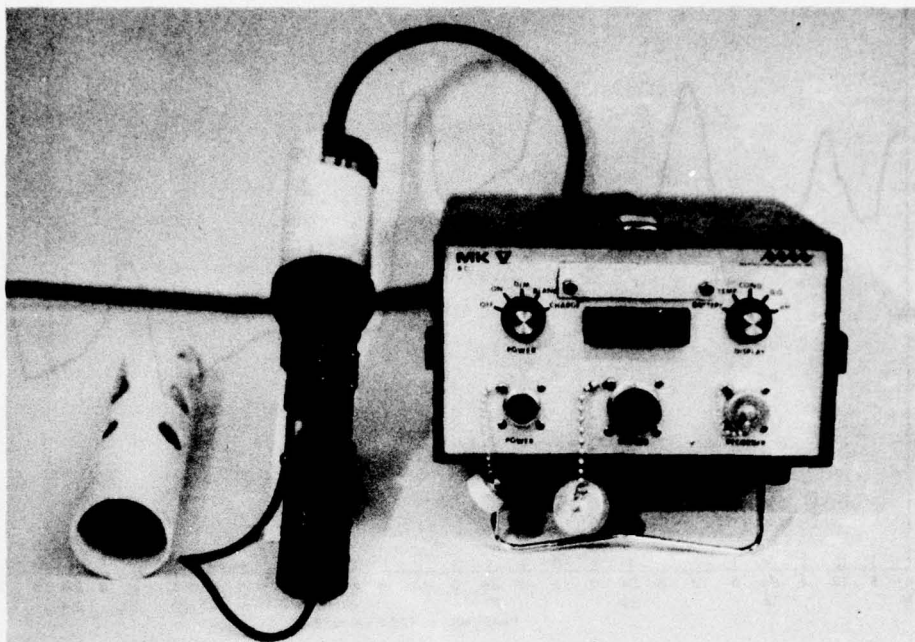


Figure 5. Martek Instruments Mark V water-quality sensor package

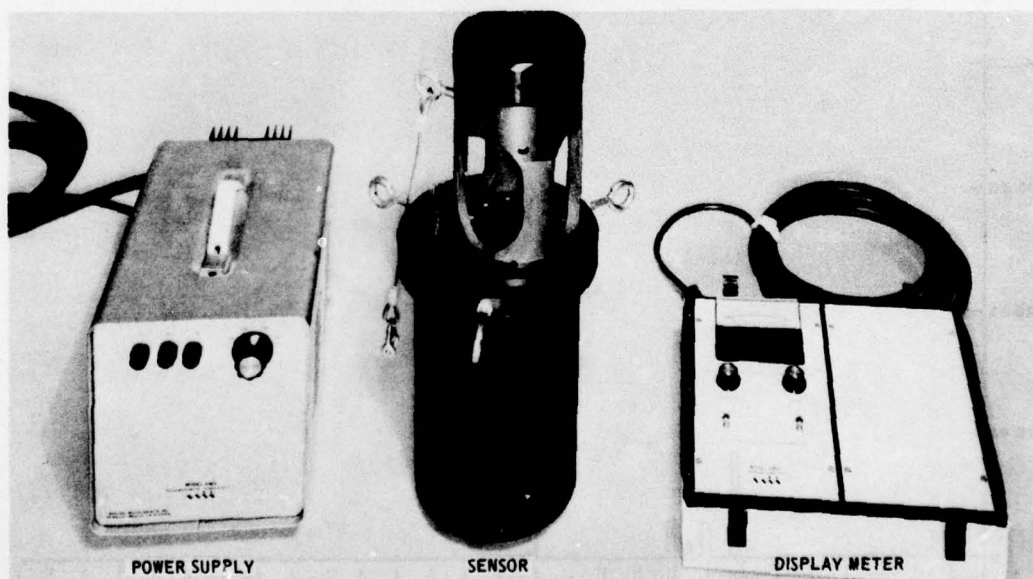


Figure 6. Martek Instruments Model XMS transmissometer (with power supply and display meter)

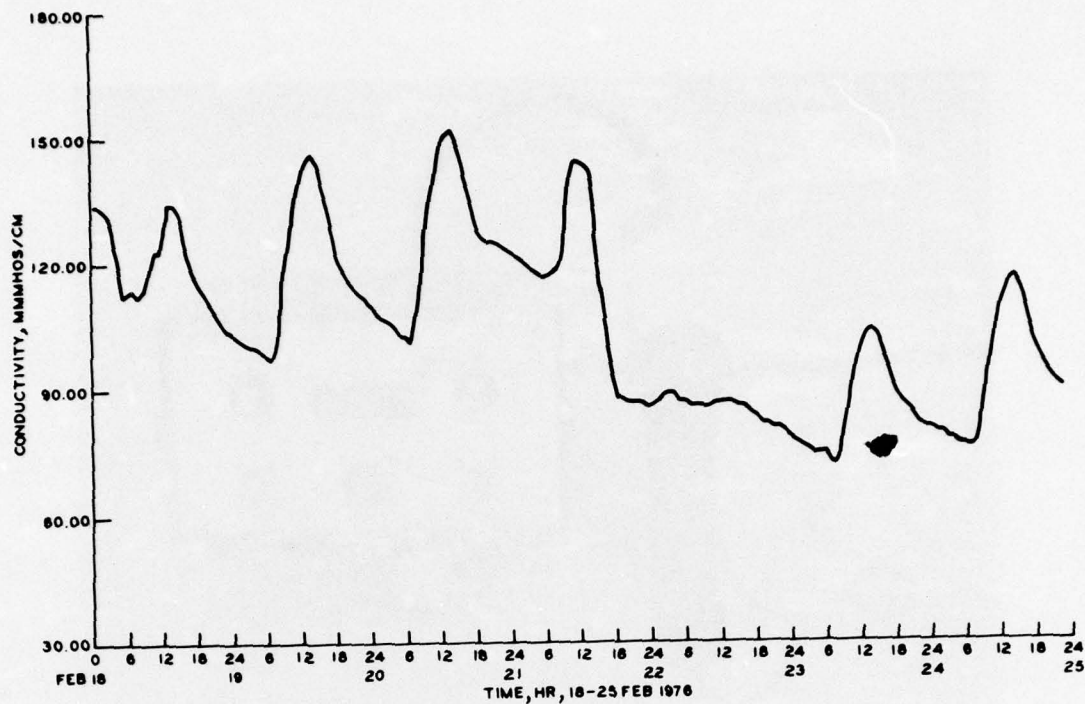


Figure 7. Conductivity measured for each 60-min sampling interval, Cane Creek, Fort McClellan, Alabama

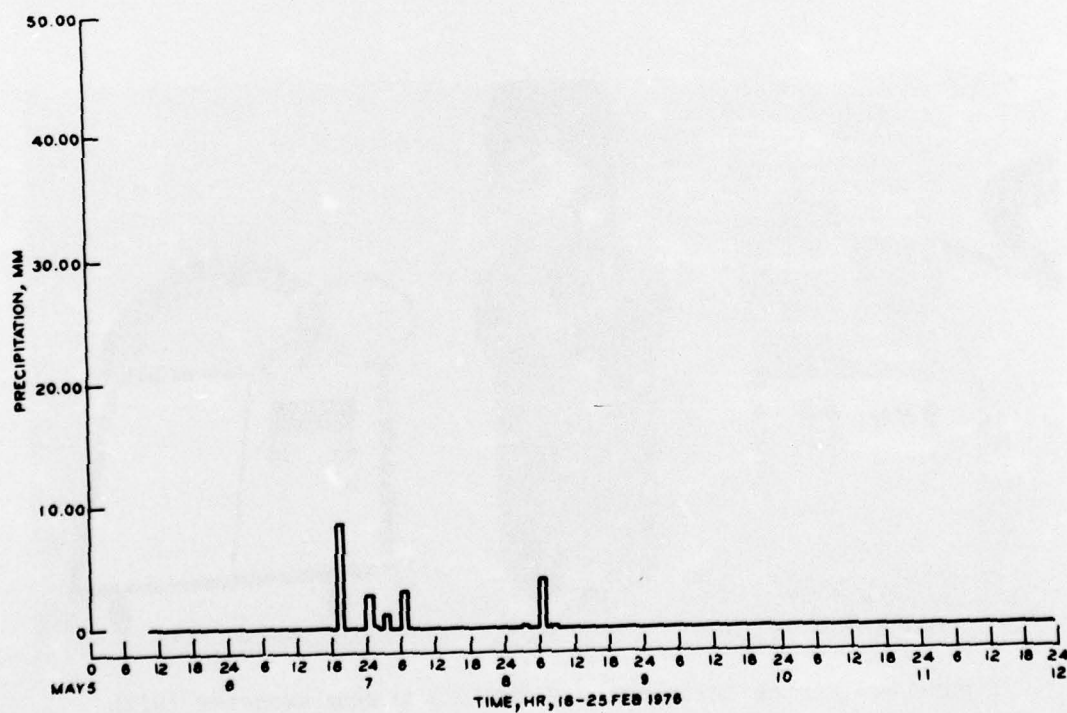


Figure 8. Precipitation measured for each 30-min sampling interval, Cane Creek, Fort McClellan, Alabama

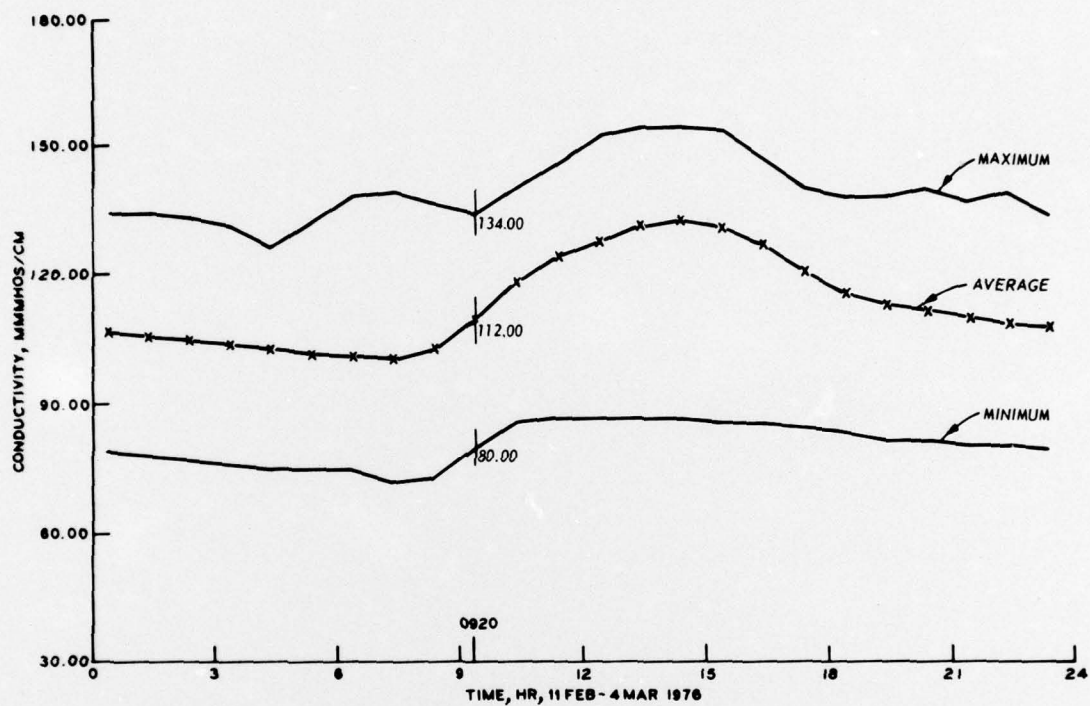


Figure 9. Maximum, minimum, and average conductivity values for 60-min sampling intervals, Cane Creek, Fort McClellan, Alabama

In accordance with ER 70-2-3, paragraph 6c(1)(b), dated 15 February 1973, a facsimile catalog card in Library of Congress format is reproduced below.

Smith, Margaret H

Water-quality and rainfall data collected with automated field station, Fort McClellan, Alabama, by Margaret H. Smith, Herman M. Floyd, and Harold W. West. Vicksburg, U. S. Army Engineer Waterways Experiment Station, 1976.

1 v. (various pagings) illus. 27 cm. (U. S. Waterways Experiment Station. Miscellaneous paper M-76-22)

Prepared for Facilities Engineering, Fort McClellan, Alabama, under Fort McClellan Environmental Program.

1. Data collection. 2. Fort McClellan, Ala. 3. Instrumentation. 4. Meteorological data. 5. Rain and rainfall. 6. Water quality. I. Floyd, Herman M., joint author. II. West, Harold W., joint author. (Series: U. S. Waterways Experiment Station, Vicksburg, Miss. Miscellaneous paper M-76-22)

TA7.W34m no.M-76-22